in the southwestern portion of the county. This large and complex aquifer shows special promise as a recycled water storage and brackish groundwater reservoir; however, additional hydrogeological investigations must be completed before the aquifer's groundwater development potential can be fully determined. **Figure 4-5** shows the location of regionally significant groundwater basins in the Authority's service area.

Although groundwater supplies are less plentiful in San Diego than in some other areas of Southern California, such as the Los Angeles Basin, sufficient undeveloped supplies exist to help meet a substantial portion of the region's future water needs. Agencies within the Authority's service area have identified more than a dozen potential groundwater recovery projects with a combined annual yield in excess of 50,000 af. The potential projects fall into three categories:

Groundwater Extraction and Disinfection Projects

These projects are generally located in basins with higher water quality levels, where extracted groundwater requires minimal treatment for use as a potable water supply. The unit cost of water produced from simple groundwater extraction and disinfection projects is usually quite low and rarely exceeds the cost of imported water. Because most of the higher quality groundwater within the Authority's service area is already being fully utilized, a relatively small amount of this "least cost" groundwater is available for the development of new supplies. Nevertheless, several agencies in the Authority's service area have identified potential extraction and disinfection projects. These projects include the initial phase of the proposed Tia Juana Valley County Water District's San Diego Formation groundwater project and several projects planned in the El Monte Basin. The average unit cost of groundwater extraction and disinfection projects proposed within the Authority's service area is approximately $300/af.

Brackish Groundwater Recovery Projects

Brackish water is typically found in basins which have been impacted by imported water irrigation or by seawater intrusion resulting from the overdraft of coastal basins. Brackish groundwater recovery projects use desalination technologies, such as reverse osmosis (RO), to treat extracted groundwater to potable water standards. The City of Oceanside's Mission Basin desalter is an example of a brackish groundwater recovery project, as is the Sweetwater Authority's proposed demineralization facility. Unit costs for brackish groundwater recovery projects are considerably higher than those for simple groundwater extraction projects due to the projects' more extensive treatment requirements and brine disposal needs. The unit costs of brackish groundwater recovery projects proposed within the Authority's service area range from $530 to $620/af.

Groundwater Recharge and Recovery Projects

Recharge projects improve groundwater basin yields by supplementing natural recharge sources with potable or recycled water. The City of San Diego's proposed San Pasqual groundwater project and the proposed Fallbrook Public Utility District/Camp Pendleton conjunctive use project are examples. The unit costs of groundwater recharge and extraction projects proposed within the Authority's service area range from $730 to $1,020/af.

4.5.2 Issues

Economic and Financial Considerations

Like recycled water projects, groundwater recovery projects can be costly to construct and operate. However, because treated groundwater is suitable for all potable uses, groundwater recovery projects face less variation in demand and do not require the construction of separate distribution facilities. Projects dependent on natural recharge sources, such as surface runoff, can be affected by hydrologic conditions and therefore provide less supply reliability than recycled water projects. Projects which use recycled water as a source of recharge are, however, highly reliable.

Institutional and Regulatory Issues

Institutional and water rights issues can be another obstacle to project development. Because most basins contain multiple water agencies, water rights is a potential concern. Agencies are often reluctant to implement groundwater development projects unless jurisdictional and water rights issues are resolved. Frequently, this reluctance stems from the ability of adjoining agencies and property owners to benefit from the groundwater project without sharing in the project costs.

Uncertainty over future regulatory requirements can pose another barrier to project development. When developing facilities and compliance plans for groundwater recharge projects, agencies must take into account proposed or potential regulatory changes. Regulations for which changes are expected over the next decade include (1) state and federal drinking water standards, (2) federal storm water regulations, and (3) DHS groundwater recharge regulations.

Environmental Constraints

Environmental issues common to many of the groundwater projects proposed within the Authority's service area include: (1) potential impacts from groundwater pumping to endangered species or groundwater-dependent vegetation and (2) impacts to other local pumpers. Such impacts may occur if a project results in seasonal or long-term increases in the depth to groundwater. Although potential environmental impacts can generally be mitigated, mitigation costs can reduce the financial feasibility of a project. Brine disposal requirements for brackish groundwater recovery projects can also be a constraint for projects sited in inland basins.

4.5.3 Opportunities

Potential Projects

Local groundwater development efforts have increased significantly since the publication of the 1993 Water Resources Plan. Agencies within the Authority's service area have identified 15 potential groundwater development projects; eight are considered to be far enough along in the planning process to support a forecasted future yield. These eight projects, presented in **Table 4-6**, range from simple extraction and disinfection projects to more highly involved projects incorporating recycled water recharge, extraction, and demineralization. One of the projects, the City of Oceanside's demineralization facility, is an expansion of an existing brackish groundwater recovery project. The other seven projects would construct new facilities.

Current conceptual planning efforts indicate that other potential projects in the Authority's service area, not identified herein, may be implemented. These projects will be monitored by the Authority for possible inclusion in the next Plan update. Based on the current level of effort and planning status of potential groundwater development projects, and assuming the continued availability of MWD incentives described in **Section 4.4.3**, this plan foresees the development of 34,400 af of additional groundwater supplies by the year 2015.

4.6 SEAWATER DESALINATION

Desalinated seawater is widely used as a potable water supply and is sometimes described as the ultimate solution to Southern California's water supply shortfall. In some areas of the world, such as the Middle East, desalinated seawater represents the primary source of potable water. Large-scale desalination projects are relatively uncommon in the United States, due to their relatively high unit costs. Nevertheless, for coastal areas such as

TABLE 4-6
Potential Groundwater Development Through 2015

Agency (Groundwater Basin)	2000 (AF)	2005 (AF)	2010 (AF)	2015 (AF)
EXISTING PROJECTS[1]				
Camp Pendleton (San Juan and Lower Santa Margarita Basins)[2]	4,400	4,400	4,400	4,400
Helix WD/Lakeside WD/Riverview WD (El Monte Basin)	2,050	2,050	2,050	2,050
City of Oceanside (Mission Basin)	2,200	2,200	2,200	2,200
Ramona MWD (Santa Maria Basin)	200	200	200	200
Sweetwater Authority (Lower Sweetwater Basin)	2,000	2,000	2,000	2,000
Yuima MWD (Pala and Pauma Basins)	2,700	2,700	2,700	2,700
Subtotal	**13,550**	**13,550**	**13,550**	**13,550**
FUTURE PROJECTS				
FPUD/Camp Pendleton (Lower Margarita River Basin)	0	2,000	4,000	6,000
Helix WD/ Lakeside WD/Riverview WD (El Monte Basin)	800	1,600	2,400	2,400
City of Oceanside (Mission Basin)	4,900	4,900	4,900	4,900
Padre Dam MWD (Santee Basin)	0	1,700	3,400	3,400
City of San Diego (San Pasqual Basin)	500	2,000	4,000	8,000
San Dieguito Valley Task Force (San Dieguito Valley)	0	2,000	4,000	4,000
Sweetwater Authority (Lower Sweetwater Basin/San Diego Formation)	1,850	3,700	3,700	3,700
Tia Juana Valley CWD (Tijuana Valley/San Diego Formation)	500	1,000	1,500	2,000
Subtotal	8,550	18,900	27,900	34,400
TOTAL	22,100	32,450	41,450	47,950

1 Vista ID currently pumps approximately 14,000 af/yr of groundwater from the Warner Basin, which it stores in Lake Henshaw. This yield is reflected in the estimated 60,000 af/yr of existing local surface water supplies.

2 Camp Pendleton typically pumps 7,800 af/yr of groundwater. The difference, 3,400 af/yr, is assumed to originate from recycled water recharged into the groundwater basin through percolation ponds.

San Diego, seawater desalination must be considered in the development of any comprehensive water resource management plan.

4.6.1 Description

Processes commonly used for large-scale seawater desalination fall into two general categories: (1) thermal processes and (2) membrane processes. Thermal processes use heat to separate salt and other impurities from seawater. Membrane processes, such as RO, use pressure to force seawater through a semi-permeable membrane. The membrane is constructed of materials which will allow water molecules, but not dissolved impurities, to pass through. Thermal facilities currently represent the largest volume of installed seawater desalination capacity. However, these facilities tend to be located in areas of the world where fuel is inexpensive. As membrane technology continues to improve, RO is gaining popularity as a less costly, more energy-efficient desalination technique.

Over the last five years, the Authority has closely studied the development of seawater desalination facilities. Earlier studies evaluated both thermal and membrane processes and concluded that RO would be the most cost effective desalination technology for this region. Subsequent studies focused on the construction of an RO facility in conjunction with the proposed repowering of the San Diego Gas and Electric South Bay Power Plant. Although the project was found to be technically feasible, many of the benefits anticipated from collocating the facility failed to materialize. As a result, the study found that environmental, regulatory, and cost issues combined to make desalinated seawater more expensive than other available water resource options.

4.6.2 Issues

Economic and Financial Considerations

As with other water supply projects, cost remains the primary barrier to project development. Despite recent advances in desalination technology, particularly in the area of lower-pressure membranes, seawater desalination remains a relatively-costly resource option.

Depending on site-specific conditions, such as the proximity of the desalination facility to brine disposal facilities and the product water distribution system, the estimated unit cost of seawater desalination projects ranges from $1,200 to $2,000/af. This makes desalinated seawater a less attractive option than competing local resources, such as recycled water and groundwater.

Environmental Constraints

Facility siting constraints can also act as a barrier to project development. Given the environmental sensitivity and land use restrictions associated with most of the San Diego County coastline, it is unlikely that many large-scale desalination facilities could be sited along the coast. Coastal power stations are among the few sites along the coastline where large desalination facilities could likely meet permitting and land use restrictions. Although desalination facilities could be sited farther inland, the expense of pumping seawater and brine concentrate over long distances would add to the already high unit costs.

When siting facilities, agencies must also consider the proximity of the site to existing potable water distribution systems. For example, the Authority's distribution system is located several miles from the coast. A large-scale coastal desalination facility would likely require a costly pipeline and pumping system to move product water inland to the Authority's distribution system. Smaller desalination facilities may be able to utilize the local distribution system to serve users along the coast.

Another significant issue affecting the development of seawater desalination facilities is disposal of the brine concentrate produced when fresh water is separated from seawater. For a typical RO seawater desalination facility, the brine concentrate discharge will have a salinity approximately twice that of the source water. Should the concentrate be discharged to the ocean, regulatory agencies are concerned that the high salt concentration could adversely impact the marine environment near the discharge point. Authority studies conducted as part of the South Bay project indicated that the salinity of the concentrate discharge could be reduced by mixing the discharge with another discharge stream, such as treated wastewater or power plant cooling water.

4.6.3 Opportunities

Emerging Technologies

Desalinated seawater does not currently appear to be a cost-effective resource option for the San Diego region. Therefore, the 1997 Plan update does not assume the development of any large-scale seawater desalination projects within the Authority's service area by the year 2015. However, ongoing efforts to develop a "breakthrough" desalination technology could change this situation. One such potential breakthrough technology is MWD's Seawater Desalination Demonstration Project, which seeks to lower desalination costs through the use of aluminum vertical tube evaporator technology.

Preliminary MWD design reports indicate that the costs of this technology, if operated on a large-scale, could be less than $600/af (excluding post-treatment and distribution costs). This cost estimate has not been verified and assumes the availability of low-cost power from a combined-cycle power plant. MWD is currently operating a test unit to evaluate the performance and cost of vertical tube evaporator technology over a wide range of conditions. If the data from the test unit show that the technology is technically and economically feasible, MWD plans to proceed with the design of a 5 mgd demonstration project. One-half of the design effort would be funded through international research and development grant funds. MWD plans to seek a suitable site and power supply for the project, preferably somewhere along the Southern California coastline.

Another potential breakthrough technology is the capacitive deionization process recently developed at the Lawrence Livermore National Laboratory (LLNL). This process utilizes a unique material called "carbon aerogel" to enhance the performance of electrodes, which remove dissolved ions from the source water. Thus far, the capacitive deionization process has only been demonstrated on a small scale in the laboratory. A larger test unit is being constructed to further evaluate the technology. Early estimates indicate that the cost of water produced could range from $400 to $600/af. However, these costs have yet to be practically demonstrated. Toward that end, the City of Carlsbad is developing a pilot plant to investigate the feasibility of the capacitive deionization process for use in large-scale brackish groundwater and seawater desalting facilities. This project, and other pilot projects based on new desalination technologies, will be monitored by staff for possible inclusion in future updates to the Plan.

4.7 SUMMARY OF LOCAL WATER SUPPLIES

The estimated costs, availability and policy considerations for various local water resources are presented in **Table 4-7**. The table does not reflect all local projects which could potentially be developed by 2015; rather, it reflects those projects for which a sufficient degree of planning has been completed to allow an assessment of their technical and financial feasibility.

TABLE 4-7
Range of Potential Normal-Year Local Resources

SOURCE	Potential 2015 Quantity (AF/YR)	Estimated Cost/AF[1]	Reliability	Regulatory/ Institutional Issues	Water Quality	Environmental Constraints	Public Acceptance
Surface Water	65,300	Minimal operation and maintenance costs	Yields vary widely depending on hydrologic	Flood control issues. Connection of existing conditions. Authority aqueducts may increase yields.	Good to excellent	CEQA compliance required. Reservoir management considerations can pose unique constraints.	High
Demand Management	81,950	$50 - $400/AF	Long-term reliability	Not applicable is unknown.	Not applicable	Not applicable	High. Active public outreach has increased knowledge and acceptance
Recycled and Repurified Water	55,000[2]	$300 - $1,200/AF	Slight reduction in project yields during droughts, otherwise highly reliable.	Regulatory issues are generally managable. Institutional issues are less of a problem for projects in the Authority's service area than in other areas of the state	Varies. Quality of recycled water is dependent on quality of influent wastewater supply. Quality of repurified water is extremely high.	CEQA compliance required. Constraints are generally construction related.	High public acceptance for recycled water. Emerging public acceptance for repurified water.
Groundwater	47,950	$300 - $1,000/AF	Varies. Yields from projects dependent on natural recharge can be affected by hydrologic conditions. Projects that use recycled water for recharge are highly reliable	Water rights are a potential for many projects	Varies depending on quality of water in groundwater basin and level of treatment.	CEQA compliance required. Unique constraints include potential impacts to groundwater dependent vegetation and impacts on existing wells. Brine disposal is an issue for some projects.	High
Desalinated Seawater	0	$1,200 - $2,000/AF	High	Requires coastal permit. Few coastal sites available.	High	CEQA compliance required. Discharge of brine concentrate can be a major issue	High

1 Costs exclude MWD and Authority financial incentives.
2 Includes 6,135 AFY of existing yield already accounted for in the Authority's demand projections and therefore not considered a new local water supply.

5.0 WATER TRANSFERS

Water transfers have emerged as one of the Authority's greatest potential resources outside of purchases from the Metropolitan Water District of Southern California (MWD). A transfer proposal currently being evaluated has the potential to result in an annual supply of water comparable to the amount the Authority purchased from MWD in 1994-95. If a transfer of this magnitude were achieved, it would fundamentally alter the relationship the Authority has with MWD, which has been the primary source of imported water throughout the Authority's history.

Current studies will determine the feasibility of transferring up to 500,000 acre-feet per year (af/yr) from one or more water sources: the Colorado River, Central California, or Northern California. This amount of water would meet more than half of the Authority's anticipated water demand in 2015. Delivering this quantity of water from the Colorado River would require either the significant enlargement or paralleling of the existing Colorado River Aqueduct (CRA) or the construction of separate conveyance facilities from Imperial Valley to the Authority. Transfers from Northern and Central California would utilize State Water Project conveyance capacity.

This Plan presents an overview of various types of transfers and evaluates transfers both as a normal-year and dry-year supply source using the same criteria as for other resource options.

5.1 OVERVIEW

Water transfers have until recently been considered by the Authority primarily as a dry-year supply. The 1993 Water Resources Plan recommended transfers only as required during a drought, for times when normal supplies from MWD were curtailed. This recommendation was based upon Authority experience during the drought that ended in 1992, MWD reduced deliveries to the Authority by as much as 31 percent. The Authority purchased enough transfer supplies from the State Water Bank to reduce the severity of that cutback to 26 percent. Using water bank transfers plus additional local supplies, the Authority was able to reduce the shortage to its member agencies to 20 percent.

Since 1993, market forces have created a situation where water transfers may be attractive as a long-term supply, to be used during normal weather years as well as insuring against droughts. The reasons for this include: passage of the Central Valley Project Improvement Act (CVPIA), increased interest in transfers from parties such as MWD and Central Valley farmers, Orange County Water District and Placer County, and the discussions between the Authority and the Imperial Irrigation District (IID). Transfers are also a consideration in the CALFED Bay-Delta process, being perceived as a contributor to overall water efficiency and as a way to supplement Delta through-flow. Normal-year transfers could diversify the Authority's sources of imported water and enhance overall supply reliability.

Water transfers typically involve purchasing water during a specified period from an agency or district that then reduces its water use by that amount. The principle behind transfers is that market forces may reallocate water. Transfers are typically categorized into the following types:

- *Spot Transfers* - Spot transfers make water available for a limited duration (typically one year or less) through a contract entered into in the same year that the water is delivered.

- *Option Transfers* - Option transfers are multi-year contracts that allow the purchaser to obtain a specified quantity of water at some future date. They usually require a minimum payment for water even if the water is not needed. For example, an agreement may require water to be purchased one out of every five years.

• *Core Transfers* - Core transfers make water available through multi-year contracts that convey a specific amount of water to the purchaser each year.

• *Storage Transfers* - Storage transfers allow the purchaser to place water into storage for delivery at some time in the future.

• *Water Exchanges* - Water exchanges are agreements between the purchasing agency and selling agency that allow for the exchange of water from one source for water from a different source.

Currently, the Authority is considering transfer opportunities involving core transfers and water exchanges. However, this Plan also reviews and evaluates other types of transfers, including spot transfers for dry years only.

Under the California Constitution, every water user has a right only to the amount of water which can be put to reasonable and beneficial use. The California Water Code (Code) empowers local agencies to sell water and to serve as brokers between individual users within their service area and potential buyers.

The Code includes statutory regulation on both short-term and long-term water transfers. Short-term transfers are for a period of one year or less, and transfers meeting these criteria are considered temporary changes. Long-term transfers, i.e., more than one year, may be approved by the State Water Resources Control Board (SWRCB) when the transfer would not result in substantial injury to any legal user and not unreasonably affect fish, wildlife, or other instream beneficial uses. Long-term transfers cannot exceed seven years, unless the transferring agency and transferee agree to a longer period.

While not a new concept, water transfers traditionally did not occur in California because of significant legal, social, and institutional barriers. A major constraint was the requirement that local water agencies, and not the transferor, have the opportunity to prevent or veto the transfer. However, during the past decade, state and federal laws were enacted to encourage transfers, based upon the premise that transfers can result in a more efficient use of water. Three key laws are highlighted in **Table 5-1**.

To gain better insight into the state of practice in water transfers, the Authority authorized a study of recent transfers in seven western states (Index of Western Water Transfers 1986-95, February 1996). The focus was on transfers of more than 10,000 acre-feet (af)

TABLE 5-1
Recent Laws Affecting Transfers

YEAR	LEGISLATION	DESCRIPTION
1986	Water Transfer Act (state)	Provides for coordinated assistance of the Department of Water Resources and other state agencies to accomplish voluntary transfers.
1986	"Katz Bill" (state) (AB 2746)	Directs public water agencies to make unused capacity in their conveyance systems available for transfers.
1992	Central Valley Project Improvement Act (CVPIA)	Permits transfers of Central Valley Project (CVP) water to areas outside of CVP service area.

occurring during 1986 through 1995. **Table 5-2** provides a list of these transfers and summarizes key information about them.

One of the most striking results of the study is how few permanent transfers involve 10,000 af or more. In California, this is probably due to statutory limitations. Results also demonstrated a wide variability in the sale price of water and indicated that the value of water is highly site-specific.

5.2 WATER TRANSFER ISSUES

One of the most important issues for any potential intrastate transfer is the inability to negotiate directly with the user of the water. Most California irrigators receiving surface waters have a contract specifying an amount of water to be delivered to them for beneficial use on their property. The actual water right is most often held by the water district or yet another agency that delivers water to the district. This is different from laws in states such as Arizona and Colorado, where rights are often held by the user and are severable from the land.

Other major issues for successful transfers are the level of compensation paid to the transferring party, environmental considerations, water quality, and the avoidance of potential harmful impacts to third parties. Third party impacts can be economic or social harm related to the transfer of water out of a region. For example, farmers who fallow lands to transfer water may have a harmful impact on farming-related businesses that produce or sell farming equipment, supplies, fuel, etc.

While all of these issues are important, the primary focus of the Authority's initial review of potential transfers is on costs, the reliability of the supply, and the quality of the water delivered. When comparing transfer options from various sources, it is also important to review the rights attached to the water. This has a direct bearing on the reliability of the transfer source and is an especially important consideration when reviewing long-term transfers for delivery during normal weather years. Although a thorough discussion of water rights is beyond the scope of this Plan, some generalizations can be made to illustrate this consideration.

Water Rights Considerations

Intrastate transfers of Colorado River water are considered the best potential source for long-term transfers because of the priority of the water. As discussed in Chapter 3, the agricultural agencies that could provide this water enjoy first through third priorities to 3.85 million acre-feet per year (maf/yr) of the state's 4.4 maf/yr allocation. These priorities are higher than MWD's Priority 4 allocation of 550,000 af. This means that the water would likely remain available for transfer even during drought, because the transferring agency, as holder of the water right, is in a relatively senior position to other water rights holders.

Depending on the source of supply, potential long-term transfers involving the State Water Project (SWP) or CVP offer varying degrees of reliability in terms of water rights. Agencies with rights dating to before 1914 are considered to have the most secure water. These agencies would be able to complete relatively secure long-term transfers. Much of this water is from an "area of origin" designation, so called because the water is located at or near the headwaters of the state's river systems. However, most of the water available for potential transfer is from the SWP and CVP contractors and has post-1914 rights. SWP and CVP rights are considered junior to area of origin rights. These agencies must apply for a permit from the SWRCB before transferring the water. In many cases, the permits must be renewed every seven years, thus clouding any long-term agreement for transfer. This issue is not as important for short-term transfers. Northern California transfer sources have provided the Authority short-term supplies in the past (1991-92 State Water Bank) and could be used for the same purpose in the future. As a practical matter, short-term transfers would be best suited as a dry-year supply.

TABLE 5-2
Representative Water Transfers 1986-95

	Number of Transfers by Year										Quantities Range (af)	Duration	Comments
STATE	86	87	88	89	90	91	92	93	94	95			
Arizona	0	0	0	0	0	0	0	0	0	0	No transfers exceeding 10,000	-----------	Type II groundwater rights transfers most prevalent type.
California	3	3	6	8	7	18	3	10	10	6	10,000 - 186,000	from 1-time only to yearly to 4 years	Ag to ag, exchanges, SWP water for CVP water, groundwater exchange, leasing storage space, environmental uses.
Colorado	0	1	0	0	0	1	1	1	2	0	10,000 - 200,000	3 1-time, 3 permanent	Storage rights, recreational/ wildlife uses, conditional rights to in-stream flow.
New Mexico	0	0	0	0	0	0	1	2	2	0	12,997 - 20,000	3 1-time, 2 year-to-year	Exchange and water for Texas.
Nevada	0	0	1	0	1	0	0	1	0	1	13,000 - 23,000	permanent	Exchange and transfer of contract right.
Utah	0	1	1	1	0	1	0	0	1	0	10,000 - 60,000	permanent	Exchange.
Wyoming	0	0	0	0	0	0	0	0	0	0	No transfers near the 10,000 range	------------	Water supply not fully appropriated.

Cost Considerations

The cost of transfer water can be divided into two general components: the acquisition cost from the transferring agency and the cost to convey the water to the Authority. The conveyance cost introduces a third party into any transfer agreement because virtually all potential transfers rely upon using MWD, SWP, and/or CVP facilities to transport (or "wheel") the water. Under current state law, these public agencies are required to provide unused capacity in their distribution systems to wheel transferred water, provided that reasonable compensation is made to cover the costs and that no harm is done to other water users. Wheeling would not be an issue if the Authority were to build a separate facility to transfer water from the Colorado River.

Wheeling

For the past few years, MWD has attempted to establish a wheeling policy that would govern how its distribution system would be made available for transfers and the compensation that MWD would consider reasonable for transfer of non-MWD water through their system. In November 1996, MWD adopted a set of principles to be used in setting wheeling rates. A short-term (less than one year) wheeling rate is expected to be set in January 1997. Long-term wheeling rates are expected to be addressed as part of a rate refinement process that MWD has conducted over the past year. Because wheeling charges could exceed the cost of transferred water, this issue will have a major impact on the total cost of transferred supplies.

Environmental

Both the Colorado River and the Bay-Delta sources of transfer raise significant environmental considerations. The environmental focus for both sources has been declining fisheries and aquatic ecosystems. These problems are discussed in more detail in Chapter 3.

Water Quality

Water quality is another important issue. Colorado River supplies are relatively high in salts, in the form of total dissolved solids (TDS), posing potential additional treatment costs. Although SWP supplies have lower salt levels, water from the Bay-Delta can be high in organic compounds that react with chlorine to form various disinfection by-products, including trihalomethanes (THMs), such as chloroform. Higher water treatment costs are incurred to eliminate these potentially harmful compounds.

5.3 TRANSFER EVALUATION METHODOLOGY

This Water Resources Plan reviews and evaluates water transfers on an overall resource basis. Specific projects have not been evaluated or recommended by the Plan. Instead, transfers are evaluated on more general considerations, such as water rights and priorities, other measures of dry- and normal-year availability, and the feasibility of accomplishing a transfer.

Specific water transfer proposals need to be evaluated on a case-by-case basis. A screening process is provided to evaluate the viability of specific water transfer proposals. Through this process, transfer proposals would be evaluated on the ability to improve reliability and local control at a cost comparable to other supply options. The overall feasibility of the transfer proposal would also be evaluated. Feasibility considerations include public and institutional acceptance, regulatory factors, third party effects, water quality, and legal issues.

Using this analytical approach, a determination can be made as to whether the cost of a specific transfer proposal is competitive with purchasing water from other sources. A water transfer "filter" was constructed to provide a framework for assessing the viability of water transfer opportunities. This filter was used to provide a preliminary evaluation of transfers from the three geographic regions where transfer water is currently available: the

Colorado River, Central California, and Northern California. While analysis of specific transfer proposals is beyond the scope of this Plan, this same methodology may be used for that purpose. **Figure 5-1** shows the transfer filter and how stages of the filter are used to determine whether a particular source of transfer water is viable. Those potential transfers which pass through each succeeding stage of the filter are considered viable.

In 1996, the Authority developed draft terms and conditions for a water transfer with the IID. These terms and conditions were derived from studies that provided detailed information about the market price for acquiring transfer water and transportation costs for delivering the water to San Diego County. While each transfer opportunity has a unique set of attributes and circumstances, assumptions were made for evaluation purposes that total costs (acquisition plus transportation) would be equivalent for core transfers from all three geographic regions. It was further assumed that core transfers would be delivered using a schedule developed under the IID proposal. These assumptions (discussed further in Chapter 7), are considered to be the best information available on the structuring of a core transfer agreement.

FIGURE 5-1
Transfer Filtering

5.4 COLORADO RIVER TRANSFER OPPORTUNITIES

The greatest amount of activity in evaluating potential Authority transfers is occurring with Colorado River supplies. Because of its potential size and scope, the IID proposal is the most visible. However, potential transfer water could also be obtained from agricultural users in Central or Northern California.

5.4.1 Transfers from the Imperial Valley

In September 1995, the Authority approved a Memorandum of Understanding (MOU) with IID to negotiate the possibility of a long-term transfer of agricultural water. Since then, the Authority Board and staff have been actively involved in exploring the feasibility of the transfer, determining the amount of water available, and negotiating its acquisition cost.

Water for the transfer would come from extraordinary conservation measures undertaken in Imperial Valley, either by the District or on the farm. IID has rights to more than 3 maf/yr of Colorado River water. Conservation measures could include improvements to irrigation systems and distribution and storage systems and better water management. An IID study completed in 1995 found that up to 400,000 af of water could be made available for transfer using these methods. Permanent removal of land from production is not one of the conservation methods being considered.

The water could be conveyed to the Authority by one of two means: either through MWD's existing CRA or through a separate facility constructed from a point on the All American Canal in Imperial Valley to the Authority. The CRA could also be modified or paralleled to increase its capacity.

An engineering feasibility study conducted for the Authority in 1996 determined several alignments that could be used for a separate facility. A new facility sized to convey 500,000 af of water would cost about $2 billion. The cost includes pipelines, tunnels, power generation and pumping facilities, water storage, and water treatment. Annual operations and maintenance (O&M) costs are projected to be about $73 million.

Projected unit costs for delivering 500,000 af of water are expected to be significantly less than the costs that were estimated for an IID transfer facility in a study conducted for the Authority in 1991. That study projected costs of $1,100/af to transport 100,000 af/yr from the Imperial Valley. The reductions in cost are from improvements in tunneling technology, lower energy costs, and achieving economies of scale.

In July 1996, the Authority and IID agreed to draft terms for a Cooperative Water Conservation and Transfer Program. The duration of the agreement is anticipated to be from 75 to 125 years. A Summary of Draft Terms for this proposal is provided in **Appendix B**. The agreement calls for 200,000-500,000 af/yr of water supply to become available to the Authority.

According to the draft terms, a quantity of 20,000 af/yr or more would be available beginning in 1999. This amount would increase annually by 20,000 af/yr for ten years to a total of 200,000 af/yr. Thereafter, the amount of water would increase annually in increments of 8,000 af/yr.

The price would be $200/af in the first year and escalate to $306/af by the tenth year (2008). A transportation cost of $75/af would bring the costs from $275/af in 1999 to $381/af in 2008. If the transportation costs exceed $75/af in this period, the base cost of water would be adjusted. The acquisition price would be reviewed every 10 years and adjusted up or down to a mutually agreeable transfer "market" price.

A number of issues are yet to be resolved that could affect this transfer. These issues include: legal, governmental, and institutional concerns; environmental impacts; water quality; third party impacts; and supply reliability. The issues are not limited to the feasibility of accomplishing the transfer, but reach to the Authority's relationship with MWD, which has historically been the Authority's sole supplier of imported water.

The transfer would have a major impact on MWD, affecting its status as regional water supplier and reducing its water sales and revenues. MWD water supply planning and capital facilities programs would be impacted. These impacts would in turn be felt by all of MWD's member agencies. The Authority is reviewing each of these issues to determine the feasibility of the transfer.

5.4.2. Other Potential Colorado River Transfers

There may be other opportunities to transfer Colorado River water to the Authority from agricultural water districts with entitlement to water from the River. These transfers could be either intra or interstate. Representative transfers that have already occurred are presented in Table 5-3.

One recent example of a potential Colorado River transfer is a proposal to transfer up to 60,000 af/yr to the Authority from the Cibola Valley Irrigation and Drainage District in Arizona. This water would come from a private party that owns more than half of the land in Cibola's service area. The state of Arizona would need to approve such a transfer, and by that state's law, any water not needed by Cibola could first be used by the Central Arizona Project (CAP), which is a major water supplier to the state for both agricultural and urban uses. This constraint and others pose significant hurdles to the transfer proposal. However, the Authority will continue to evaluate the proposal as a potential resource.

5.5 NORTHERN AND CENTRAL CALIFORNIA TRANSFER OPPORTUNITIES

Northern California represents another potential source of transfer water for the Authority. At this time, no proposal exists comparable to the IID transfer evaluation. However, the recent legislation discussed in Section 5.1 has increased the likelihood of future transfers and water marketing.

As also discussed in Section 5.1, while intrastate transfers are simple in concept, they are difficult to achieve because of legal and

TABLE 5-3
Transactions Involving Colorado River Water

Year	Seller	Buyer	Regltry Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1993	Central Arizona Water Conser-vation District	MWD	Bureau	89,000	$70-114	4 years	Water stored underground in Arizona for future exchange.
1992	Palo Verde ID	MWD	Bureau	186,000	$135	2-year test program	Ag acres fallowed and water stored in Lake Mead.
1988	IID	MWD	Bureau	106,000	$120	35 years	Improvements to IID's delivery system.

institutional constraints. The largest obstacle is that most transfers can only be accomplished with the consent of the water district or agency transferring the water. For example, if an irrigator in the San Joaquin Valley wanted to quit farming and sell water to San Diego, depending on the source of water and amount to be transferred, that irrigator may need the consent of the water district delivering his water.

Potential transfers from the central and northern parts of the state would have to move through the SWP, the CVP, or both. The water would also have to be conveyed through the MWD system. Water pumping costs through the SWP are significantly higher than through the CRA, and it could be expected that wheeling water through the SWP would cost more than through the CRA. Transfer water from the CVP is also subject to a CVP transfer fee of about $50 per af. This fee is for recovery of capital facilities debt service and is in addition to the cost of acquisition. Depending on hydrologic conditions, transfers from north of the Delta may also have a requirement to provide carriage water for environmental purposes. This is currently estimated to be up to 35 percent of every acre-foot transported through the Delta, which would add about $60 per af to the cost of north-of-the-Delta transfers.

One of the key issues for transfers from Central and Northern California is the potential impact that exports from the Delta would have on the Bay-Delta ecosystems. Future transfers would likely have to meet the operating requirements yet to be established by CALFED, as discussed in more detail in Chapter 3. Because of these operating requirements, transfers south of the Delta would probably encounter fewer constraints than those north of the Delta. However, a limiting factor for south of the Delta transports is that groundwater basins are significantly overdrafted. State policy explicitly limits the substitution of transferred surface water with groundwater extracted from an overdrafted basin.

5.5.1 State Water Project

The SWP has significant excess capacity, even during normal years, that could be used for wheeling supplies transferred from Central or Northern California. Recent transfers using the SWP are given in **Table 5-4**.

Perhaps the best example for how such transfers could be made, and what they would cost, is the State Water Bank created during the end of the recent drought. In 1991, as a drought emergency measure, DWR created the bank to enable water-short districts and agencies to purchase supplies from willing water sellers. DWR purchased the water supplies primarily from Northern California agricultural entities and sold these supplies to entities experiencing drought shortages. DWR purchased the water for $125/af and sold it for $175/af. MWD purchased 215,000 af in 1991; the Authority purchased 21,600 af. The bank still exists, and **Table 5-5** shows some of its major recent transactions.

5.5.2 Central Valley Project

The sources of water for the CVP are the Sacramento and San Joaquin rivers and their tributaries. On average, the CVP delivers about 7.3 maf to 250 contractors, making it the largest water project in California.

Transfers among CVP contractors or users on an informal basis have been common for years. Between 1981 and 1989, more than 1,200 such transfers were made to meet agricultural irrigation needs. **Table 5-6** shows some of the larger recent transfers. Because these transfers do not require a change in the Bureau's water rights permits for the CVP, they are not subject to SWRCB jurisdiction.

In addition to transfers between individual contractors, two groups of contractors have set up permanent transfer pooling systems. The Sacramento River Contractors Association entered into a pooling agreement in 1974, and the Tehama-Colusa Canal Authority set up one in 1981. The pools establish banks where participants can deposit water when they have excess and withdraw water when they need it.

TABLE 5-4
Transfers Involving SWP Supplies

Year	Seller	Buyer	Reg. Agency	(AF)	Amount ($/AF)	Price Duration	Comments
1995	Kern County Water Agency (KCWA)	Tulare Lake Basin Water Services District	DWR	41,500	Unknown	one-time	Ag to ag
1995	KCWA	Westlands WD (WWD)	DWR	10,875	Unknown	one-time	Exchange
1995	KCWA	WWD	DWR	49,803	Unknown	one-time	Ag to ag
1995	Dudley Ridge WD	WWD	DWR	14,446	Unknown	one-time	Ag to ag
1995	MWD	Coachella Valley WD (CVWD)	DWR	23,100	Unknown	yearly	SWP water for CRA water
1995	MWD	Desert Water Agency (DWA)	DWR	38,100	Unknown	yearly	SWP for CRA
1994	MWD	CVWD	DWR	14,102	Unknown	yearly	SWP for CRA
1994	MWD	DWA	DWR	23,257	Unknown	yearly	SWP for CRA
1993	MWD	CVWD	DWR	23,100	Unknown	yearly	SWP for CRA
1993	MWD	DWA	DWR	38,100	Unknown	yearly	SWP for CRA
1993	KCWA	WWD	DWR	77,600	Unknown	one-time	Exchange
1993	KCWA	WWD	DWR	10,000	Unknown	one-time	Ag to ag
1993	Semitropic WSD	MWD	DWR	50,000	Unknown	one-time	Leasing storage space for 1992 MWD SWP entitlement
1990	MWD	CVWD	DWR	23,100	Unknown	yearly	SWP for CRA
1990	MWD	DWA	DWR	38,100	Unknown	yearly	SWP for CRA
1989	MWD	CVWD	DWR	21,873	Unknown	yearly	SWP for CRA
1989	MWD	DWA	DWR	36,500	Unknown	yearly	SWP for CRA
1989	KCWA	WWD	DWR	55,000	Unknown	one-time	SWP for CRA
1988	MWD	CVWD	DWR	20,652	Unknown	yearly	SWP for CRA
1988	MWD	DWA	DWR	34,000	Unknown	yearly	SWP for CRA
1987	MWD	CVWD	DWR	19,341	Unknown	yearly	SWP for CRA
1987	MWD	DWA	DWR	31,500	Unknown	yearly	SWP for CRA
1986	MWD	CVWD	DWR	18,210	Unknown	yearly	SWP for CRA
1986	MWD	DWA	DWR	29,000	Unknown	yearly	SWP for CRA

TABLE 5-5
Transfers Involving the State Water Bank

Year	Seller	Buyer	Reg Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1994	Sac'to River Water Contractors Assn.	State Water Bank	DWR	25,000	$50	one-time	Groundwater exchange
1994	Placer County Water Agency	State Water Bank	DWR	20,000	$50	one-time	Reservoir storage
1992	Oakdale ID/S. San Joaquin ID	State Water Bank	DWR	50,000	$50	one-time	Groundwater exchange
1992	Merced ID	State Water Bank	DWR	11,705	$50	one-time	Reservoir storage
1991	Joint Water District Board	State Water Bank	DWR	60,000	$125	one-time	Groundwater exchange
1991	Orville-Wyandotte ID	State Water Bank	DWR	10,000	$125	one-time	Reservoir storage
1991	Yuba County Water Agency	State Water Bank	DWR	127,200	$125	one-time	Reservoir storage
1991	Brophy WD	State Water Bank	DWR	36,000	$125	one-time	Groundwater recharge
1991	Raminez WD	State Water Bank	DWR	13,277	$125	one-time	Groundwater recharge
1991	South Yuba WD	State Water Bank	DWR	17,000	$125	one-time	Groundwater recharge
1991	Western Canal WD	State Water Bank	DWR	40,000	$125	one-time	Groundwater recharge
1991	RD 1044	State Water Bank	DWR	24,077	$125	one-time	Groundwater recharge
1991	Conaway Conservancy	State Water Bank	DWR	44,774	$125	one-time	Groundwater recharge

TABLE 5-6
Transfers Involving CVP Supplies

Year	Seller	Buyer	Reg Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1994	San Luis Canal Co.	Water Acquisition Program	Bureau	12,000	$50	one-time	Environmental uses
1994	Western Canal WD	Water Acq. Prog	Bureau	82,403	$50	one-time	Environmental uses
1994	Richvale ID	Water Acq. Prog	Bureau	31,825	$50	one-time	Environmental uses
1994	Ramirez WD	Water Acq. Prog	Bureau	12,658	$50	one-time	Environmental uses
1994	Bureau	Kern Natl Wildlife Refuge	Bureau	12,473	n/c	one-time	Environmental uses
1993	Bureau	Kern Natl Wildlife Refuge	Bureau	12,552	n/c	one-time	Environmental uses
1993	Central Calif ID	Westlands WD	Bureau	18,000	$18.07	one-time	Ag to ag
1993	San Luis Canal Co.	Panoche WD	Bureau	10,000	$17.52	one-time	Ag to ag
1993	San Luis Canal Co.	Westlands WD	Bureau	12,000	$18.07	one-time	Ag to ag
1989	Bureau	Calif Dept of Fish & Game (DFG)	Bureau	30,000	n/c	one-time	Environmental uses
1989	Bureau	DWR	Bureau	10,000	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	100,000	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	85,500	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	126,500	Unknown	one-time	Environmental uses
1986	Bureau	DFG	Bureau	100,000	Unknown	one-time	Environmental uses

TABLE 5-7
Range of Potential Transfer Water Sources

Source	Potential Amount (AF/YR)	Est. Cost (1996 $/AF)	Main Issues
Colorado River - IID and other intrastate	0-500,000	275-383	Feasibility of potential new facility, long-term cost and reliability, water quality, environmental impacts, conservation measures.
Colorado River - interstate	0-60,000	275-383	Interstate legal/feasibility considerations, length of term, cost, and reliability.
Northern California - SWP	0-150,000	275-383	Long-term reliability, cost, Bay-Delta operational and facilities restrictions.
Northern California - CVP	0-150,000	275-383	Long-term reliability, cost, Bay-Delta operational and facilities restrictions.

Passage of the CVPIA has provided the opportunity for CVP water to be considered a major potential resource for Southern California. The CVPIA allows not only districts but individual farmers to transfer water. Districts only have veto rights if the transfer is more than 20 percent of their contracted CVP supply. These requirements have simplified the transfer of CVP water to other areas of the state. As a result of the CVPIA, MWD is pursuing CVP and other transfers to meet the goal of MWD's Integrated Resources Plan (IRP) of providing 460,000 af of transfer water during a dry year.

5.6 SUMMARY OF POTENTIAL TRANSFER SUPPLIES

Table 5-7 summarizes potential transfers that are considered and evaluated in this Plan.

6.0 DEVELOPMENT OF ALTERNATIVES

Six basic water resources mixes were evaluated in this Plan. The alternatives vary primarily upon the source of imported water, whether from the Metropolitan Water District of Southern California (MWD) or through long-term transfers, and upon the amount of local resources that could be developed. This chapter describes the development of the alternatives. Chapter 7 presents an evaluation of the alternatives, using a standard set of resources selection criteria, and Chapter 8 recommends one of the alternatives for future development.

6.1 OVERVIEW

Under existing conditions, the Authority receives all of its water supplies from MWD. The region relies upon this water for about 70 percent of its needs during wet years, 80 percent during normal years, and up to 95 percent during dry years. The remaining supplies are obtained from local sources, primarily surface water runoff into reservoirs. The significance of this situation is that local surface water supplies are weather-dependent and highly variable and that the Authority has relatively few supply options during dry years to offset shortages that MWD may experience.

Accordingly, this Water Resources Plan emphasizes developing alternatives that increase the diversity of the Authority's supply, especially during dry years. Diversity of supply is considered a key element of reliability, giving the Authority the ability to draw upon multiple sources of supply during future dry years. The alternatives developed in this plan evaluate opportunities to increase the sources of both local and imported water supplies.

The recent six-year drought provided an illustration of the benefits of having a diverse supply. The Authority was not subject to water shortages during the first four years of the 1986-92 drought because three primary sources of water were available: the Colorado River, the State Water Project (SWP), and local surface water. Those areas of the state that were solely dependent on the SWP or local surface waters were affected immediately and suffered severe cutbacks during the initial years of drought. It was only when the drought entered into a fifth year that severe shortages on the SWP caused MWD to implement drought allocations. That experience led to an emphasis in resources planning of creating a diversified mix of water resources. Uncertainties that affect long-term supplies from both the SWP and Colorado River have also pointed to the need for diversification.

Recent opportunities for water transfers and local water supply development have dramatically changed the potential mix of water resources that the Authority could pursue. These opportunities could significantly enhance reliability. Large-scale transfers, in particular, have made possible the consideration of resource mixes that reduce the MWD component of supply to as low as 20 percent of the total 2015 normal year demand. By comparison, the 1993 Water Resources Plan recommended a mix of supplies in which MWD met 82 percent of 2010 demand.

6.2 RECOMMENDATIONS OF THE 1993 PLAN

The development of alternatives in the 1997 Water Resources Plan is best understood within the framework of the recommendations of the 1993 Plan and the subsequent emergence of potential new water supplies. The Authority's 1993 Water Resources Plan sought to enhance reliability by diversifying the sources of supply and reducing dependence on MWD. A specific mix of resources, including water conservation, was recommended for development by 2010. Table 6-1 provides highlights of the resources

TABLE 6-1
1993 Water Resources Plan Recommended Resources

Demand/Supply (AF)	1995	2000	2005	2010
Normal Demand	709,000	789,000	842,000	902,000
Conservation	21,000	37,000	52,000	70,000
Existing Local Supply	60,000	60,000	60,000	60,000
Water Recycling	11,000	18,000	36,000	50,000
Groundwater	2,000	5,000	10,000	15,000
Desalination	0	0	0	20,000
MWD Required	615,000	669,000	684,000	687,000

recommended in the 1993 Plan.

The 1993 Plan noted that the Authority's imported supply from MWD had suffered a shortage of 31 percent in 1991, during the fifth year of a drought. This shortage would have been greater if water transfers had not been arranged by MWD through the State Water Bank. The 1993 Plan anticipated that the Authority would need dry-year transfers of 75,000 acre-feet (af) by 2010 to meet its own reliability goal. However, transfers were not part of any normal-year resources option.

The 1993 Plan concluded that, even after undertaking an ambitious effort to develop local supplies, the Authority would continue to be dependent upon MWD for a substantial portion of its total water needs. The most striking difference between the resource mixes being considered in this Plan and those considered in the 1993 Plan is the emphasis placed on the potential use of water transfers as a normal-year supply option. The 1993 Plan examined alternatives that relied on MWD for 70-82 percent of the total supply; this Plan evaluates resource mixes under which MWD would provide 20-85 percent of the supply.

6.3 WATER RESOURCES ALTERNATIVES

Six major water resources alternatives are considered in this Plan. Each alternative was designed with a specific goal in mind. The first alternative was designed as a base case and continues the strategy used in the 1993 Plan. The remaining alternatives were designed to evaluate: varying levels of transfers that would be conveyed through the CRA or SWP, maximum levels of local supply development, and the construction of a separate water conveyance facility to receive Colorado River water. Each alternative was also designed to meet or exceed the Authority's current water reliability goal. All alternatives assume a 2015 demand of 787,000 acre-feet per year (af/yr), adjusted for demand management (water conservation).

An economic optimization computer model was used to refine the alternatives. This model, developed for the Authority by Regional Economic Research, Inc. (RER), of San Diego, identifies the least cost mix of local and imported water resources under given sets of constraints and assumptions. This provided an opportunity to identify the most cost-effective mix of resources given a set of specific conditions. In this way, quantities for each potential component of supply were identified, and the lowest cost possible for the specified conditions was determined. Water resource costs were based on information from MWD, local agencies, the July 1996 Summary of Draft Terms for transferring water from the Imperial Irrigation District

(IID), and an engineering feasibility study for Colorado River conveyance facilities. Cost assumptions are discussed in detail in Chapter 7.

Existing Strategy Alternative.

This baseline alternative would continue the resources strategy recommended in the 1993 Water Resources Plan. The mix of resources recommended would change from the 1993 Plan to reflect updated cost estimates of both local and imported supplies, as well as revised demand forecasts. However, the 1993 resources development goal would be retained: to pursue an intermediate amount of cost-effective local supplies that would meet the Authority's reliability goal.

This represents a baseline case for the economic optimization model. Local resources only appear in this alternative if they are cost-competitive with projected supplies from MWD (based upon average MWD costs), or if they are already operating or under construction. This alternative does not utilize transfers during normal weather years. Rate sensitivity was performed by increasing MWD's projected baseline water rate by 3 percent annually beginning in 2002, the last year covered by the Phase 1 Rate Refinement Process. A similar sensitivity analysis was also performed for the other alternatives.

Maximum Local Supply Alternative.

This alternative was designed to determine the costs and benefits of developing the maximum amount of local supplies, including recycling, repurification, groundwater, and seawater desalination. It shows the minimum amount of MWD supply that would be required if local resources were developed at the maximum level, both with and without normal-year transfers. Using a maximum effort, local resources, including local surface water, would account for 185,000 af of supply, or 24 percent of the Authority's 2015 supply, assuming 60,000 af/yr from existing sources.

For modeling purposes, the Maximum Local Supply Alternative uses the same general conditions as the baseline case, but makes an assumption that all local recycling, groundwater, and seawater desalination projects at a certain planning stage would be constructed. This affects both the total cost of the alternative and the amount of imported water required to meet total demand (there is not sufficient local supply to meet all demand). This is the only alternative in which seawater desalination appears as a resource; the model was "forced" to select it In other alternatives, desalination was not selected because of its relatively high cost. A separate run of the model was conducted to determine local resources that would result if 200,000 af/yr were developed as long-term transfers, this time without forcing the model to accept seawater desalination.

A sensitivity analysis was performed using the high range of MWD rates. The increase in rates not only increases the costs paid for imported water, but increases the share of local project costs that Authority member agencies bear, because MWD local supply development incentives are tied to the level of MWD rates.

Maximum Local Supply With Transfers Alternative.

This alternative is patterned after the Maximum Local Supply Alternative with two major exceptions: transfers of up to 200,000 af/yr would be developed and conveyed through the SWP or CRA, and seawater desalination would not be pursued. All other local supplies were selected based on cost-effectiveness. Under this alternative, MWD supplies would constitute 54 percent of the Authority's total mix, transfers would comprise 25 percent, and local supplies 21 percent.

The Maximum Local Supply with Transfers Alternative was modeled to wheel 200,000 af/yr. It would "construct " only the most cost-effective local supply projects. This analysis constrained the model to accept a schedule of transfers beginning at 20,000 af/yr in 1999 and increasing by 20,000 af/yr increments until 200,000 af/yr is reached in 2008. Transfers were left at this maximum annual level from 2009 through 2015.

Intermediate Transfers Alternative.

This alternative is based on developing an intermediate level (200,000 af/yr) of long-term, core water transfers. The normal-year transfers would be conveyed through the CRA or SWP. The Intermediate Transfers Alternative was modeled using the same assumptions regarding acquisition costs, transportation costs, and scheduled deliveries of transfers as the preceding alternative (Maximum Local Supply with Transfers). However, this alternative would construct only the most cost-effective local supply projects. By 2015, the Authority's supply mix under this alternative would be 60 percent MWD, 25 percent transfer, and 15 percent local. The 60 percent level of supply from MWD would make the Authority resemble the "average" MWD member agency in terms of water supply and would more closely match the Authority's preferential rights to MWD water.

Maximum Transfers Alternative.

This alternative explores the maximum anticipated level of transfer without constructing new, separate facilities. A transfer amount of 500,000 af/yr was modeled. Similar to the Intermediate Transfers Alternative, transfer deliveries begin in 1999, with 20,000 af/yr. This is ramped up by 20,000 af/yr increments until 200,000 af/yr is reached in 2008. After this point, deliveries increase by 50,000 af/yr until 2014, when 500,000 af/yr is reached. After that point, deliveries would remain at 500,000 af/yr during normal years.

Water from this alternative could be from a combination of Colorado River and Northern or Central California origin. However, it is assumed that the maximum amount of transfer water available within Northern and Central California is 150,000 af/yr, leaving 350,000 af/yr to come from the Colorado River.

Colorado River Facilities Alternative.

The final alternative modeled was a conveyance facility that would be constructed from San Diego County to the Imperial Valley to transport 500,000 af/yr. Because of high salinity levels, this water would be treated using reverse osmosis demineralization technology, which would cause estimated water losses of 13 percent, or 65,000 af/yr. Therefore, the total annual supply from this alternative would be 435,000 af/yr.

Table 6-2 provides a summary of the water that would be developed under each alternative. The quantities of supply were determined by the economic optimization model, except for transfers and seawater desalination. **Appendix C** provides detailed information about the model and the assumptions made for operating it.

TABLE 6-2
Summary of Supply Amounts for Alternatives
(Based on Normal-Year 2015 Demand of 787,000 AF)

Alternative	MWD	Transf	Existing Local	Recl Water[1]	Ground Water	Seawater Desal
Existing Strategy	671,000	-	60,000	24,000	32,000	-
Maximum Local	602,000	-	60,000	60,000	45,000	20,000
Maximum Local W/ Transfers	422,000	200,000	60,000	60,000	45,000	-
Intermediate Transfers	465,000	200,000	60,000	30,000	32,000	-
Maximum Transfers	165,000	500,000	60,000	30,000	32,000	-
CR Facilities	230,000	435,000[2]	60,000	30,000	32,000	-

1 Includes repurification.
2 Adjusts for demineralization losses of 65,000 af/yr.

7.0 ANALYSIS OF ALTERNATIVES

The primary objective of the Water Resources Plan is to identify a resources alternative that best meets the needs of the Authority through 2015. This chapter presents the methodology and the evaluation processes used to determine the selection of a water resources mix. The alternatives evaluated, listed below, were developed in Chapter 6.

- Existing Strategy Alternative
- Maximum Local Supply Alternative
- Maximum Local Supply With Transfers Alternative
- Intermediate Transfers Alternative
- Maximum Transfers Alternative
- Colorado River Facilities Alternative

7.1 OVERVIEW

Alternatives analysis focused on seven criteria used to select the mix of resources best meeting the Authority's needs for a safe and reliable water supply. The criteria, listed in **Table 7-1**, are defined in more detail later in this chapter. Two of the criteria are based upon quantitative analyses, and the approach taken is a straightforward ranking of alternatives. These criteria are the total cost of the alternative and the potential impact that implementation of the alternative would have on water rates. The remaining criteria are more subjective, and the decision-making process relied upon judgment calls regarding issues of reliability, feasibility, water quality, degree of Authority control over the resource, and estimated environmental impacts.

The Authority conducted a public outreach program as part of the Water Resources Plan update. The Authority received input from a variety of individuals, community organizations, and interest groups on key water demand and supply issues. Individual interviews were conducted with representatives of these groups to obtain their viewpoints, and a weighting exercise was held for the water resources selection criteria to determine the relative importance of each criterion. Detailed results of the public outreach program are given in **Appendix A**.

As a general rule, stakeholders tended to rank rate impacts and reliability as the two most important criteria in the weighting exercise. This concern was also voiced during the

TABLE 7-1 Evaluation Criteria

CRITERION	DESCRIPTION
1. Cost	Minimize total cost of the alternative from 1996-2015.
2. Degree of Authority Control	Maximize control Authority has over water supplies.
3. Environmental Impacts	Minimize amount of environmental harm.
4. Feasibility	Maximize confidence that resources will be developed.
5. Rate Impacts	Minimize water rate increases.
6. Reliability	Maximize supply availability.
7. Water Quality	Minimize salinity and other undesirable parameters.

interviews. Results of the outreach program were used as a qualitative tool in the evaluation of the alternatives; the criteria were not numerically weighted for use in the evaluation.

7.2 QUANTITATIVE CRITERIA EVALUATION

This section presents evaluation results for the two resources selection criteria that are quantitative: minimize total cost and minimize rate impacts. Evaluation results for these criteria are based upon the computer optimization model and a separate Authority rate modeling analysis. The remaining five criteria are considered qualitative and involve subjective evaluations. These criteria are evaluated in Section 7.3.

7.2.1 Criterion: Minimize Total Cost

Definition of Criterion: This criterion measures the total cost of each alternative from the Authority's perspective over the 20-year planning horizon of the Water Resources Plan (1996-2015). Costs include water purchases; capital, operations, and maintenance costs for local water supply projects; and estimated demand management costs. Metropolitan Water District of Southern California (MWD) costs are measured by projected water rates and associated charges, including the Readiness-to-Serve Charge (RTS). Water transfer costs are divided into acquisition costs, or the cost of purchasing the supply from the transferring party, and transportation costs, which include "wheeling" charges from MWD, the State Water Project (SWP), or other conveyance facilities owners. Total cost is net of financial incentives for supply development provided by MWD, the federal government, or others. Avoided costs are also calculated, where applicable, to reduce the total cost of an alternative.

Analysis and Results.

The Authority's economic optimization computer model, H2Optimum, was used to derive least-cost resource mixes for each alternative. Under the constraints identified in each alternative, the model selected the least costly mix of resources over the 20-year planning horizon. Total costs were calculated net of benefits and avoided costs and expressed as a Net Present Value (NPV) in 1996 dollars. The costs do not represent the alternatives' actual monetary costs. However, the costs can be used for economic comparisons between and among alternatives.

The model used detailed data on the costs of individual local supply projects, water transfers, conservation programs, and future MWD water rates and charges. Additional information was collected on the avoided costs resulting from local supply projects or water transfers. Avoided costs include savings resulting from the deferred construction of an Authority Pipeline 6 and avoided treatment plant expansion resulting from local supplies and conservation. Outside funding sources were identified, including MWD incentives and federal construction grants, that would reduce the cost of supply development to the Authority or its member agencies.

Water rate projections provided by MWD staff were used to estimate the cost of MWD deliveries under each of the alternative resource mixes. In order to determine the sensitivity of each alternative to increases in MWD rates, Authority staff developed a high rate projection by assuming that MWD commodity rates increase by 3 percent annually after 2002. The rates used to conduct the cost analyses in the Water Resources Plan are provided in **Appendix C**.

MWD staff provided the Authority with rate projections under three scenarios: a no transfer scenario, a 200,000 acre-feet per year (af/yr) transfer scenario, and a 500,000 af/yr transfer scenario. These rate projections reflect the outcome of the Phase 1 Rate Refinement and Cost Containment processes completed in July 1996. As a result of the Cost Containment Process, MWD's capital improvement program

(CIP) was reduced by $200 million, from $4.1 billion to $3.9 billion, and additional savings were achieved by the deferral of certain capital expenditures. The Phase 1 Rate Refinement Process (RRP) resulted in the temporary suspension of the New Demand Charge (NDC). MWD adopted the NDC in 1996 as a means of paying for those facilities needed to serve new demand. The rate projections provided to the Authority assume that revenues which would have been collected through the NDC will be collected through the basic water rate. The potential impact of a reinstated NDC on the cost of the six alternatives is discussed in greater detail in Section 7.2.3.

Least-cost planning principles generally utilize the cost of water shortages to find an "optimum" cost position. This position is a balance between expected shortage costs and the cost necessary to prevent the shortage from occurring. Much recent work has been done in this field for water supply, including studies of observable losses and contingent valuation studies, in which respondent surveys are used to elicit responses that can be used to estimate the value of water supply reliability.

As part of its optimization modeling effort, Regional Economic Research, Inc. (RER), reviewed existing studies on the economic damages inflicted by water shortages. In general, it was found that these studies produced questionable monetary values for shortages. Therefore, they were not directly used in the modeling effort to locate the optimum least-cost position. However, because the studies consistently indicated a strong public aversion to shortages, RER concluded that the public did place a high value on the avoidance of shortages. The RER results of this study are given in **Appendix D**.

The economic optimization model was used to derive the total cost of each alternative under low and high supply cost assumptions. The upper range of costs was obtained by using the high projected MWD water rates for each alternative and assuming that the market rate for transfers increases by 25 percent after 10 years, pursuant to the escalation formula outlined in the Summary of Draft Terms between the Authority and the Imperial Irrigation District (IID) for the conservation and transfer of water **(Appendix B)**. The lower range of costs was obtained by using low MWD rate projections for each alternative and by assuming the acquisition price for transfer water falls by 25 percent after 10 years, as outlined in the Summary of the Draft Terms. Transfer acquisition costs are provided in **Table C-1 of Appendix C**.

Transportation costs for transfer water were based on an Authority proposal to MWD, which provides for a wheeling charge consisting of incremental operations and maintenance (O&M) and power costs. MWD's incremental cost of transporting water through the Colorado River Aqueduct (CRA) is estimated at $58 per acre-feet (af): $40 for power and $18 for O&M. MWD's cost to transport State Project water is estimated at $115 per af: $70 for power and $45 for O&M. For the purposes of the total cost analysis, a $75/af wheeling charge was used. Total costs for Northern California transfers were assumed to equal those for Colorado River transfers, with lower acquisition costs offsetting higher transportation costs. MWD is finalizing its wheeling policy, and the outcome of that process will influence the results of this analysis. To the extent that the wheeling charge is substantially different from the amount used in this Plan, the total cost and rate impact criterion will require reevaluation.

The analysis performed for the Colorado River Facilities Alternative was based on cost estimates contained in a study titled *Feasibility Level Engineering for Facilities to Transfer Water from the Imperial Irrigation District* (Feasibility Study). The Feasibility Study identified five alternative pipeline corridors and associated treatment and pumping facilities. Feasibility level cost estimates were prepared for facilities sized to convey from 300,000 to 500,000 af/yr.

The purpose of the Feasibility Study was to develop a range of costs for conveyance facilities, rather than to identify a single low-cost alternative. The cost estimates do suggest, however, that there are economies of scale associated with larger capacity facilities. The total cost analysis prepared for this Plan assumed the construction of conveyance facilities with a capacity of 500,000 af/yr along a central corridor identified in the Feasibility Study as Corridor 5A.

The total capital cost of the conveyance pipeline and associated facilities, excluding those facilities included in the Authority's Emergency Water Storage Project (ESP), is estimated in the Feasibility Study at $1.85 billion in 1996 dollars. Power costs, estimated at $41.9 million, were assumed to remain level throughout the planning period. Remaining operating costs, estimated at $31.9 million, were assumed to increase by 3 percent annually beginning in 1997. The brine stream from the demineralization process is estimated at 65,000 af/yr, reducing the facilities' net yield to 435,000 af/yr.

The total cost to the Authority of the Colorado River Facilities Alternative may be affected by the availability of outside funding. Potential funding sources include a public-private partnership, the U.S. federal government, and Mexico, which has expressed interest in financial participation in some form of a joint project. Because of uncertainties relating to these outside funding sources, the total cost analysis assumes that Authority water rates represent the sole source of funding for the conveyance facilities.

The results of the total cost economic analysis and the alternatives' ratings for the total cost criterion are presented in **Table 7-2**. The total costs are not the monetary costs of each alternative, or the cost that the Authority would actually incur for implementing the alternative. The total costs are instead an economic evaluation of each alternative's capital and O&M costs, in 1996 dollars, net of certain avoided costs for facilities construction and water treatment and financial contributions from MWD, the state, and the federal government.

Total costs for the Existing Strategy, Intermediate Transfers, and Maximum Transfers Alternatives were found to be the lowest. Total costs for these alternatives ranged from $3.33 to $3.58 billion. The total cost of the Maximum Local Supply With Transfers Alternative, while somewhat higher, was still lower than that of the Maximum Local Supply

TABLE 7-2 Water Resources Plan 1997 Update
Comparative Evaluation of Total Cost

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
Total Cost (billion)[2]	3.33- 3.57	3.53- 3.99	3.47-3.66	3.37-3.58	3.35-3.58	3.78-4.03
RATING	●	○	▨	●	●	○

● Good ▨ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.

[2] Expressed as net present value in 1996 dollars

Alternative. Total costs for the Colorado River Facilities and Maximum Local Supply Alternatives, which ranged from $3.53 to $4.03 billion, were significantly higher than those of the other alternatives. Those alternatives' higher total costs were contributable both to larger capital requirements and higher O&M costs. The Colorado River Facilities Alternative assumes the use of reverse osmosis (RO), an energy-intensive process, to reduce the salinity of the transfer water. The Maximum Local Supply Alternative includes two seawater desalination projects, which also require large amounts of power. The upper range of costs for all alternatives was heavily influenced by the use of high MWD rate projections.

The facilities contemplated under the Colorado River Conveyance Facilities Alternative would have a useful life of 50 years or more, making the alternative difficult to analyze within the context of a twenty-year planning document. Because the conveyance facilities were assumed to begin operation in 2012, only four years of amortized capital costs were included in the alternative's total cost. If the analysis were extended beyond 2015, the total cost would more accurately reflect the alternative's total costs and benefits.

In each of the resource mixes, all conservation Best Management Practices (BMPs) were implemented. Conservation consistently proved to be the lowest cost source of water for the Authority under any conditions modeled. This is because of both the low cost to implement the BMPs and the availability of outside funding to reduce Authority and member agency costs.

7.2.2 Criterion: Minimize Water Rate Impacts

Definition of Criterion: This criterion measures potential impacts on water rates. Each alternative is evaluated for potential upward pressure on Authority and Authority member agency water rates. Alternatives in which costs increase gradually are considered superior to those in which costs escalate rapidly.

Analysis and Results.

Each of the resource mixes analyzed in this Plan includes a local supply element which will be funded by local agencies. In keeping with the total cost analysis in Section 7.2.1, the financial analysis conducted for the Plan considers expenditures at both the regional and the local agency levels. Alternatives with the highest combined regional and local agency costs are assumed to have the highest potential rate impacts. The analysis does not provide a forecast of water rates at either the Authority or the local agency level. However, it does allow a comparison among alternatives of the potential need for future rate increases.

Local costs are defined as local agencies' costs of building, operating, and maintaining local supply projects, less MWD and Authority financial incentives; the cost of operating local reservoirs; and the cost of conservation incentive programs. Not included in the financial analysis are water treatment costs, local agency storage and delivery costs, and costs borne directly by consumers (e.g., conservation devices purchased and installed by consumers). For purposes of this analysis, it is assumed that the cost of treatment to meet Safe Drinking Water Act primary standards is equal regardless of whether the water is treated locally or by MWD. Those alternatives with local projects that do not require surface water treatment are credited for that avoided cost.

Table 7-3 provides a summary of the assumptions used in the analysis of each alternative. More detailed information is provided in **Appendix C**. Water rate projections were developed by MWD for a "base case" (i.e., no transfer) scenario and two transfer scenarios: 200,000 af/yr and 500,000 af/yr. These rate projections were used to develop a "low" cost estimate for each alternative. MWD's projected 2002 water rates were increased by 3 percent annually during the remainder of the planning period to obtain a "high" base case. The high

TABLE 7-3
Summary of Financial Analysis Assumptions

Alternative	2015 MWD Untreated Water Rate[1]	Wheeling Charge	Transfer Acquisition Cost	Transfer Quantity	Local Projects Developed
Existing Strategy	$434- 543/af	Not applicable.	Not applicable.	None.	Projects under construction and future projects that are cost effective from a regional perspective.
Maximum Local Supply	$434-543/af	Not applicable.	Not applicable.	None.	All local projects that have completed completed a minimum level of plan-ning.
Maximum Local Supply With Transfers	$455-570/af	$75/af in 1999 non-power costs increase by 3 percent annually.	$306/af by 2008, cost decreases to $231/af in 2009 under the low cost scenerio and in-creases to $385/af in 2008 under the high cost scenerio. [2]	Increases by 20.000 af/yr from 20.000 af in 1999 to 200,000 af by 2008. Quantity fixed at 200,000 af/yr thereafter. [3]	All local projects that have completed a minimum level of planning except seawater desalination projects.
Intermediate Transfers	$455-570/af	Same as above.	Same as above.	Same as above.	Projects under construction and future projects that are cost effective from a regional perspective.
Maximum Transfers	$535- 670/af	Same as above.	Same as above.	200.000 af/yr by 2008, 50,000 af/yr increase thereafter to 500,000 af/yr.[3]	Same as above.
Colorado River Facilities[4]	$535-670/af	Same as above. Wheeling charges end in 2012 when conveyance facilities begin operation.	Same as above.	200.000 af/yr by 2008. Increases to 500,000 af/yr in 2012.[3]	Same as above.

1 Low range rates provided by MWD. High range rates produced by escalating MWD rates by 3%/yr after 2002. All rate scenarios assume a fixed RTS share of $27.9 million after 2001 and the continuation of agricultural and seasonal storage discounts.
2 Costs adjusted as per the Summary of Draft Terms for transferring water from the IID.
3 Quantities for the years 1999 - 2008 adjusted as per the Summary of Draft Terms for transferring water from the IID.
4 Facility capital costs are assumed to be financed with a combination of cash, short-term debt, and 40-year bonds. The Authority is not authorized under its enabling act to issue 40-year debt; financing of the conveyance facilities through this mechanism would require action by the State Legislature.